

**PCT**

WORLD INTELLECTUAL PROPERTY ORGANIZATION  
International Bureau



INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

<b>(51) International Patent Classification <sup>7</sup> :</b> <b>H04N 9/73</b>	<b>A1</b>	<b>(11) International Publication Number:</b> <b>WO 00/10331</b> <b>(43) International Publication Date:</b> 24 February 2000 (24.02.00)
<b>(21) International Application Number:</b> PCT/EP99/05595 <b>(22) International Filing Date:</b> 3 August 1999 (03.08.99)  <b>(30) Priority Data:</b> 98202727.8 14 August 1998 (14.08.98) EP  <b>(71) Applicant:</b> KONINKLIJKE PHILIPS ELECTRONICS N.V. [NL/NL]; Groenewoudseweg 1, NL-5621 BA Eindhoven (NL).  <b>(72) Inventor:</b> JASPERS, Cornelis, A., M.; Prof. Holstlaan 6, NL-5656 AA Eindhoven (NL).  <b>(74) Agent:</b> STEENBEEK, Leonardus, J.; Internationaal Octrooibureau B.V., Prof. Holstlaan 6, NL-5656 AA Eindhoven (NL).		<b>(81) Designated States:</b> JP, KR, European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).  <b>Published</b> <i>With international search report.</i>
<b>(54) Title:</b> COLOR SIGNAL MATRIX ADJUSTMENT  <b>(57) Abstract</b>  In a color signal matrix adjustment method, a single first color signal matrix related value is adjusted (VAC) to obtain a color signal matrix adjustment, and at least two color signal matrix parameters other than the single first color signal matrix related value are automatically adapted (AAC) in dependence upon the color signal matrix parameter adjustment.		

**FOR THE PURPOSES OF INFORMATION ONLY**

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	ES	Spain	LS	Lesotho	SI	Slovenia
AM	Armenia	FI	Finland	LT	Lithuania	SK	Slovakia
AT	Austria	FR	France	LU	Luxembourg	SN	Senegal
AU	Australia	GA	Gabon	LV	Latvia	SZ	Swaziland
AZ	Azerbaijan	GB	United Kingdom	MC	Monaco	TD	Chad
BA	Bosnia and Herzegovina	GE	Georgia	MD	Republic of Moldova	TG	Togo
BB	Barbados	GH	Ghana	MG	Madagascar	TJ	Tajikistan
BE	Belgium	GN	Guinea	MK	The former Yugoslav Republic of Macedonia	TM	Turkmenistan
BF	Burkina Faso	GR	Greece			TR	Turkey
BG	Bulgaria	HU	Hungary	ML	Mali	TT	Trinidad and Tobago
BJ	Benin	IE	Ireland	MN	Mongolia	UA	Ukraine
BR	Brazil	IL	Israel	MR	Mauritania	UG	Uganda
BY	Belarus	IS	Iceland	MW	Malawi	US	United States of America
CA	Canada	IT	Italy	MX	Mexico	UZ	Uzbekistan
CF	Central African Republic	JP	Japan	NE	Niger	VN	Viet Nam
CG	Congo	KE	Kenya	NL	Netherlands	YU	Yugoslavia
CH	Switzerland	KG	Kyrgyzstan	NO	Norway	ZW	Zimbabwe
CI	Côte d'Ivoire	KP	Democratic People's Republic of Korea	NZ	New Zealand		
CM	Cameroon			PL	Poland		
CN	China	KR	Republic of Korea	PT	Portugal		
CU	Cuba	KZ	Kazakstan	RO	Romania		
CZ	Czech Republic	LC	Saint Lucia	RU	Russian Federation		
DE	Germany	LI	Liechtenstein	SD	Sudan		
DK	Denmark	LK	Sri Lanka	SE	Sweden		
EE	Estonia	LR	Liberia	SG	Singapore		

## Color signal matrix adjustment.

The invention relates to a method of and device for a color signal matrix adjustment, and to a color camera comprising such a color signal matrix adjustment device.

5 Every color sensor needs a correction of its given colors towards the EBU Red-Green-Blue primaries which are accustomed in worldwide television sets and PC monitors. For the color correction a matrix with nine variables is applied. The RGB color matrix serves in the following equation:

$$\begin{bmatrix} Ro \\ Go \\ Bo \end{bmatrix} = \begin{bmatrix} a11 & a12 & a13 \\ a21 & a22 & a23 \\ a31 & a32 & a33 \end{bmatrix} \times \begin{bmatrix} Ri \\ Gi \\ Bi \end{bmatrix}$$

Herein, Ri, Gi, Bi are the input RGB signals of the image sensor, Ro, Go, Bo are the output  
10 RGB signals which are close to the EBU primaries or otherwise more desired (e.g. in that the picture just looks nicer) than the input RGB signals, and a11 ... a33 are the color signal matrix parameters, viz. a11 ... a13 for Red, a21...a23 for Green, and a31 ... a33 for Blue.

If one of the color signal matrix parameters a11 ... a33 is changed to obtain a desired change in one output color, also the white reproduction will be changed as an  
15 undesired side-effect. This makes a manual adjustment of the output colors very difficult and time consuming.

Besides the desired correction of RGB colors, commonly also the white point of the image generated by the sensor has to be corrected. The white reproduction depends on the RGB spectral power distribution of the sensor itself and of the color temperature of the scene  
20 illumination. That white reproduction has to be adjusted to D65 or close to D65 white of the EBU display standard. The white reproduction via the color signal matrix is represented by the sum of the matrix variables of each color:

$$\Sigma R = a11 + a12 + a13$$

$$\Sigma G = a21 + a22 + a23$$

25  $\Sigma B = a31 + a32 + a33$

It is however almost impossible to change the three selected matrix parameters of one color proportionally in order to achieve a desired white point.

US-A-5,402,182 discloses an automatic white balance controlling apparatus for controlling the white balance of an image screen by controlling the color signal level in accordance with an up-down counting result in a micro-computer.

It is, inter alia, an object of the invention to provide a very simple matrix adjustment. To this end, a first aspect of the invention provides a method and a device as defined by claims 1 and 5. A second aspect of the invention, defined by claim 6, provides a color camera comprising such a matrix adjustment device. Advantageous embodiments are defined in the dependent claims.

In a color signal matrix adjustment method in accordance with a primary aspect of the invention, only a single first color signal matrix related value is adjusted to obtain a desired color signal matrix adjustment, and at least two color signal matrix parameters other than the single first color signal matrix related value are automatically adapted in dependence upon the color signal matrix parameter adjustment.

These and other aspects of the invention will be apparent from and elucidated with reference to the embodiments described hereinafter.

20

The drawing shows an embodiment of a color camera in accordance with the present invention.

25

In accordance with a preferred embodiment of the present invention, the desired white and RGB color adjustment can much easier be achieved with the aid of a RISC core (or any other kind of computing power) in the camera, and with the above-mentioned color signal matrix formulas.

30

A primary application of the invention relates to a color signal matrix adjustment with the aid of RISC core. There are four possibilities for adjusting the matrix to the desired colors. The selection of a possibility, and switching from one to another and back,

1. The conventional method by changing one matrix parameter at a time.
2. Changing one matrix parameter at a time, but with maintenance of the white reproduction to a large extent in accordance with a first aspect of the present invention.
3. For white adjustment, three matrix parameters can be changed simultaneously.
- 5 4. For white amplitude adaptation, all nine matrix parameters can be changed proportionally to each other.

The first possibility needs of course no further explanation. The selected color as well as the white reproduction will change.

- 10 The second possibility, offering the maintenance of the white reproduction to a large extent by selecting first a Boolean B1 to distinguish it from the first possibility, uses the calculation power of a RISC core. If one matrix parameter of a color X is changed with a value  $\pm\delta$ , then all six matrix parameters not belonging to the selected color X (i.e. those in the two other rows), are multiplied by  $(\Sigma X \pm \delta) / \Sigma X$ , where  $\Sigma X$  corresponds with the selected Red,
- 15 Green or Blue matrix row sums. After that new  $\Sigma R$ ,  $\Sigma G$  and  $\Sigma B$  values are calculated. They will be proportional to the previous values before the adjustment, so the white reproduction will be maintained to a large extent. White is fully maintained if the  $\Sigma R$ ,  $\Sigma G$  and  $\Sigma B$  values are equal to 1; a slight white shift occurs if the  $\Sigma R$ ,  $\Sigma G$  and  $\Sigma B$  values differ from 1. However, this slight white shift can easily be corrected in accordance with the third possibility described
- 20 below.

In accordance with the third and fourth possibilities, the white reproduction is changed with maintenance of the ratio of the matrix parameters for each color.

- 25 The third possibility, indicated by a second Boolean B2, concerns the adjustment of the white reproduction with only one single parameter, again with the aid of a RISC core. If the white reproduction has to be changed, one of the  $\Sigma R$ ,  $\Sigma G$  or  $\Sigma B$  matrix row sums is selected and changed. The RISC core takes care of a proportionally change of the corresponding matrix parameters. For example, if  $\Sigma R$  is increased by  $\pm\delta$ , then the matrix
- 30 parameters  $a_{11}$ ,  $a_{12}$  and  $a_{13}$  are each multiplied by  $(\Sigma R \pm \delta) / \Sigma R$ , finally resulting in a desired white shift. The direction of the color vector for Red will get a small deviation that is determined by the amount of white shift only.

The fourth possibility, again using a RISC core, concerns the adjustment of all matrix parameters proportionally to each other in order to adapt the signal amplitude of the matrix circuit to a more unity value. Select first a Boolean B3 that makes clear that all parameters have to be changed proportionally. Then select one of the  $\Sigma R$ ,  $\Sigma G$  or  $\Sigma B$  matrix row sums. Vary this matrix row sum by  $\pm\delta$ . Next all matrix parameters will be multiplied by  $(\Sigma X \pm \delta) / \Sigma X$ , where  $\Sigma X$  corresponds with the selected  $\Sigma R$ ,  $\Sigma G$  or  $\Sigma B$  matrix row sum. Thereafter, the new  $\Sigma R$ ,  $\Sigma G$  and  $\Sigma B$  matrix row sums are calculated again. The color as well as the white reproduction will be maintained, only the signal amplitudes will be changed.

The following conclusions can be drawn. Using all proposed possibilities will help to adjust the matrix much easier then when using only the first possibility. All mentioned adjustment possibilities have been realized with a PC and a menu for the selection of the matrix parameters a11 to a33,  $\Sigma R$ ,  $\Sigma G$  or  $\Sigma B$  and two Boolean, one for white maintenance and one for amplitude adjustment.

A primary aspect of the invention can be summarized as follows. Besides the theoretical calculation of the matrix for color correction, also a manual adjustment for further fine-tuning or as a check with several pictures is required. Tuning the color matrix of a camera to a desired color reproduction means however that nine parameters have to adjusted. A specific problem with such a matrix is that if one parameter, in for instance the red matrix, is changed that besides the red also the white reproduction changes. By maintaining the white reproduction with the aid of the calculation power of the RISC core (Reduced Instruction Set Computer) of the camera it has become much easier to adjust the matrix to the desired color reproduction. Moreover it is also possible to change directly the white reproduction. The deviation of the color reproduction will then be determined by the deviation of the white reproduction only.

The following features are especially noteworthy. The possibility of maintaining the white reproduction when changing one of the selected matrix parameters a11 to a33. Changing the white reproduction by selection of  $\Sigma R$ ,  $\Sigma G$  or  $\Sigma B$  with maintenance of the matrix ratio of each color and with a color shift that is only determined by the amount of white shift. The proportional adaptation of the signal amplitudes by changing all matrix parameters proportionally to each other by selecting an amplitude Boolean and  $\Sigma R$ ,  $\Sigma G$  or  $\Sigma B$ . The use of

The drawing shows an embodiment of a color camera in accordance with the present invention. A sensor S supplies three input color signals  $R_i$ ,  $B_i$  and  $G_i$ . A matrix adjustment device VAC, CC, AAC receiving these input color signals  $R_i$ ,  $B_i$  and  $G_i$  comprises  
5 a value adjustment circuit VAC for adjusting a color matrix related value which may be one of the nine matrix parameters  $a_{11} \dots a_{33}$  or one of the three matrix row sums  $\Sigma R$ ,  $\Sigma G$  or  $\Sigma B$ . A control circuit CC comprises three buttons  $B_1$ ,  $B_2$ ,  $B_3$  to switch on or off the three above-mentioned Booleans  $B_1$ ,  $B_2$  or  $B_3$ , respectively. An automatic adapting circuit AAC adapts the matrix parameters as described above with regard to the four above-mentioned  
10 possibilities, and supplies the output color signals  $R_o$ ,  $G_o$  and  $B_o$ .

It should be noted that the above-mentioned embodiments illustrate rather than limit the invention, and that those skilled in the art will be able to design many alternative embodiments without departing from the scope of the appended claims. In the claims, any  
15 reference signs placed between parentheses shall not be construed as limiting the claim. The word "comprising" does not exclude the presence of other elements or steps than those listed in a claim. The invention can be implemented by means of hardware comprising several distinct elements, and by means of a suitably programmed computer. In the device claim enumerating several means, several of these means can be embodied by one and the same item  
20 of hardware.

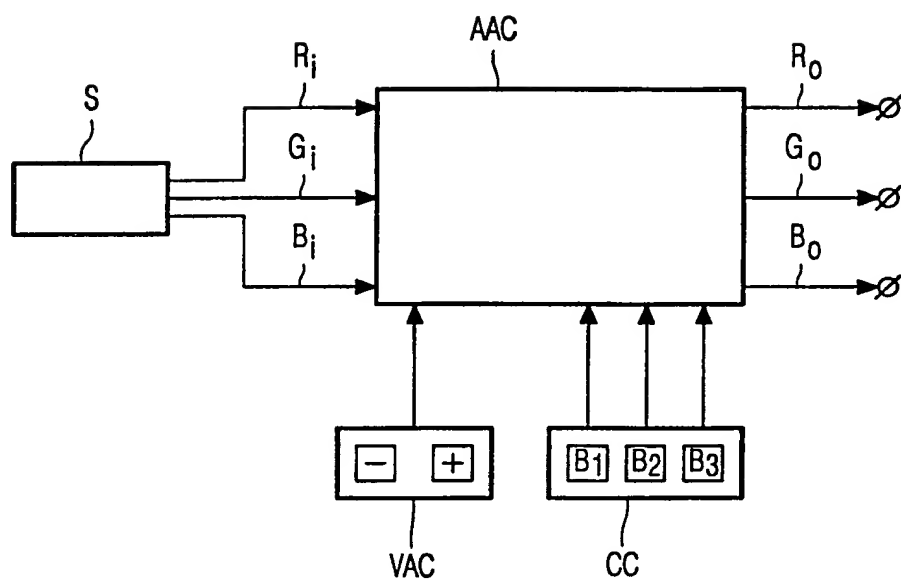
## CLAIMS:

1. A color signal matrix adjustment method, comprising:  
adjusting (VAC) a single first color signal matrix related value to obtain a color  
signal matrix adjustment; and  
automatically adapting (AAC) at least two color signal matrix parameters other  
5 than said single first color signal matrix related value in dependence upon said color signal  
matrix parameter adjustment.
2. A method as claimed in claim 1, wherein said single first color signal matrix  
related value is a first color signal matrix parameter corresponding to a first color, said color  
10 signal matrix adjustment is an increase of said first color signal matrix parameter by an amount  
 $\delta$  to change a reproduction of said first color, and said automatically adapting step includes  
multiplying all color matrix parameters corresponding to colors other than said first color by a  
factor  $(\Sigma X + \delta) / \Sigma X$ , in which  $\Sigma X$  is a sum of color signal matrix parameters corresponding to  
said first color, to maintain a white reproduction to a large extent.
- 15 3. A method as claimed in claim 1, wherein said single first color signal matrix  
related value is a sum  $\Sigma X$  of color signal matrix parameters corresponding to a first color, said  
color signal matrix adjustment is an increase of said sum  $\Sigma X$  of color signal matrix parameters  
by an amount  $\delta$  to change a reproduction of both said first color and white, and said  
20 automatically adapting step includes multiplying all color matrix parameters corresponding to  
said first color by a factor  $(\Sigma X + \delta) / \Sigma X$  to maintain a ratio between said color matrix  
parameters corresponding to said first color.



4. A method as claimed in claim 1, wherein said single first color signal matrix related value is a sum  $\Sigma X$  of color signal matrix parameters corresponding to a first color, said color signal matrix adjustment is an increase of said sum  $\Sigma X$  of color signal matrix parameters by an amount  $\delta$  to change color signal amplitudes, and said automatically adapting step
- 5 includes multiplying all color matrix parameters by a factor  $(\Sigma X + \delta) / \Sigma X$  to maintain a reproduction of both said first color and white.
5. A color signal matrix adjustment device (AAC, VAC, CC), comprising:
- means (VAC) for adjusting a single first color signal matrix related value to
- 10 obtain a color signal matrix adjustment; and
- means (AAC) for automatically adapting at least two color signal matrix parameters other than said single first color signal matrix related value in dependence upon said color signal matrix parameter adjustment.
- 15 6. A color camera, comprising:
- a color sensor (S) for producing input color signals (Ri, Gi, Bi); and
- a color signal matrix adjustment device (AAC, VAC, CC) as claimed in claim 5 for adjusting said input color signals (Ri, Gi, Bi) to obtain output color signals (Ro, Go, Bo).

1/1



# INTERNATIONAL SEARCH REPORT

Inte. onal Application No

PCT/EP 99/05595

**A. CLASSIFICATION OF SUBJECT MATTER**  
IPC 7 H04N9/73

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 H04N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category ?	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 0 800 318 A (SONY CORP) 8 October 1997 (1997-10-08) abstract column 2, line 23 -column 3, line 15 column 5, line 35 - line 16; figure 1 column 8, line 1 - line 58; figure 2 ---	1,5
A	PATENT ABSTRACTS OF JAPAN vol. 015, no. 110 (E-1046), 15 March 1991 (1991-03-15) & JP 03 003497 A (HITACHI LTD), 9 January 1991 (1991-01-09) abstract -----	1,5

☐

Further documents are listed in the continuation of box C.

☒

Patent family members are listed in annex.

**Special categories of cited documents :**

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search

9 November 1999

Date of mailing of the international search report

15/11/1999

Name and mailing address of the ISA

European Patent Office, P.O. Box 5818, D-6800 Mannheim 2

Authorized officer

# INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PC1, EP 99/05595

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0800318 A	08-10-1997	CN 1168597 A JP 10276443 A	24-12-1997 13-10-1998
JP 03003497 A	09-01-1991	NONE	